Vernal pool conservation in the Agate Desert, near Medford, Oregon

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Introduction

Vernal pools are a characteristic feature of the Agate Desert, a unique mounded prairie surface located in the Rogue Valley in Jackson County, Oregon, U.S.A. Agricultural and urban development have altered most of the desert, leaving only scattered undisturbed tracts. Among the unique biota associated with the remaining vernal pools are a threatened species of fairy shrimp (*Branchinecta lynchi*) and two endangered species of plants, large-flowered woolly meadowfoam (*Limnanthes floccosa* ssp. *grandiflora*) and Cook's lomatium (*Lomatium cookii*). The presence of federally listed species has prompted conservation efforts to identify and preserve essential remaining vernal pool habitat and a program to characterize and monitor habitat and biota. Here we describe the conservation program and report preliminary results on water quality, zooplankton population development and the vegetation community of three representative sites.

Key words: vernal pool, Agate Desert, fairy shrimp, wetland conservation

Geological setting: The Agate Desert

The vernal pools of the Rogue River plain form seasonally on the patterned ground surface of the Agate Desert surrounding the unincorporated community of White City. The Agate Desert is delineated based on four features (ELLIOT & SAMMONS 1996):

- Alluvial gravel terrace
- Yellowish-red, well-oxidized surface
- Shallow, well-indurated duripan
- Development of patterned ground

Although the mechanisms that gave rise to the patterned ground are debated, evidence indicates that it appeared in its present form during the Pleistocene. The duripan layer, 30–60 cm below the surface, supports the seasonal perched water and the appearance of vernal pools on the surface between November and May when seasonal rainfall exceeds evapotranspiration (HANES & STROMBERG 1996).

The Agate Desert once supported the most extensive system of vernal pools in the region. Of the original 8300 ha of Agate Desert, approximately 40% retains some of its original topography and hydrology, although altered by development and often invaded by non-native, mostly agricultural, vegetation. Less than 15% of the original habitat is nearly intact, and very little of that has received permanent protection. The area in and around White City contains about half the intact topography of the region and is the subject of the conservation effort described here.

Wetland conservation plan/habitat conservation plan

The Agate Desert has experienced increasing development because of its proximity to the urban and industrial areas of the nearby city of Medford. Local, state and federal agencies, as well as private parties, are working to address habitat and wetland conservation around White City. Timely completion of a successful conservation program is essential because little of the original habitat remains.

Jackson County is working to develop a Wetland Conservation Plan (WCP) to integrate state wetland regulations with land use planning in the Agate Desert area. The WCP will include an inventory of all wetlands, an assessment of their qualities, allocation of parcels into protection or development categories, and implementation mechanisms via county land use ordinances. Before the WCP can be completed, it must be coordinated with state regulations for wetland fill permitting, to assure consistency with the protection, conservation and best use of water resources, including aquatic life or habitats and rare, threatened or endangered species listed under the federal Endangered Species Act of 1973, as amended (the Act). The WCP will also provide the informa-

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tion necessary for a biological assessment under Section 10 of the Act for a Habitat Conservation Plan (HCP) and associated Incidental Take Permit. Financial assistance from the U.S. Fish and Wildlife Service through section 6 of the Act has recently been designated to prepare a federal HCP tiered to the state WCP to meet requirements of the Act while providing for both conservation and development needs. The tiered WCP/HCP identifies the best places for development and those areas suitable for preservation, and establishes a compromise between economic development, habitat protection and species conservation. After state and federal approval, the county will implement the plan by adopting local ordinances in the county comprehensive plan. Together, the WCP and HCP will conserve and restore habitat for several species and provide an efficient regulatory clearance process for landowners, the community and the regulatory agencies. Once these plans are in place, individual permit review will be much faster and outcomes more predictable.

By June 2004, a little over 200 ha had been identified for development, 500 ha had been proposed for protection, and approximately 800 ha were included in an "incentives" category for which the final designated use is under consideration. The planning process is scheduled for completion by the end of June 2005.

Habitat and biota characterization and monitoring

Vernal pools may not interact directly with other nearby clusters of vernal pools and are usually little affected by regional changes in the use of deeper aquifers. Accordingly, they must be studied at the local scale of vernal pool catchment. However, because uplands, vernal pools and streams are potentially interconnected, local changes in land use can affect vernal pools down gradient (RAINS et al. in press). Because the remaining Agate Desert vernal pool habitat is inter-dispersed among various types of altered land use, the proper functioning of the tracts selected for preservation may be influenced by changes in land use on adjacent tracts.

A general characteristic of freshwater zooplankton is the existence of long-lived diapausing life stages (HAIRSTON 1996). This ability is particularly developed in the Anostraca, or fairy shrimp, and other zooplankton characteristic of vernal pools. Diapause is seen as a bet-hedging adaptation (PHILIPPI et al. 2001) to the unpredictable duration of the ponding phase, and has important implications for dispersal in time and space (BOHONAK & JENKINS 2003). Accordingly, any strategy for the protection of threatened or endangered species of fairy shrimp implies a focus on habitat conservation (BELK 1996). A question of particular interest is whether the habitat requirements of the species of concern will be supplied by preservation efforts (ALEXANDER & SCHLISING 1996).

The three tracts selected for habitat characterization and monitoring represent somewhat different histories and contrasting surrounding land use. The purpose of the habitat study is to provide information essential to support the conservation plan described above and to track the effectiveness of the preservation effort. The three sites are:

Nature Conservancy Site (TNC): 21.4 ha, located 42°26.7′N, 122°53.3′W. This site was purchased by The Nature Conservancy in 1987 and has been managed for preservation of vernal pool habitat. Adjacent land use is light industry and cattle grazing. The vernal pools at this site are considered to be near original condition and little influenced by adjacent land use. *B. lynchi* have been recorded in almost 40% of the pools at this site, although not all in the same year.

School Site (School): 10.1 ha, located 42°26.3′N, 122° 49.7′W. This site was set aside by Jackson County School District #9 as an education and conservation site in 2002. The site had been used for cattle grazing and off-road vehicle use for many years. In spite of the neglect, the original topography remains largely intact and populations of fairy shrimp have been observed in some of the remaining pools. Surrounding land use is primarily residential, which may influence water quality on the site.

Denman Site (Denman): 720 ha, located 42°26.5′N, 122°52.3′W. This site was originally set aside as a wildlife conservation area in 1964. Although not specifically managed for vernal pool conservation, parts of the tract con-

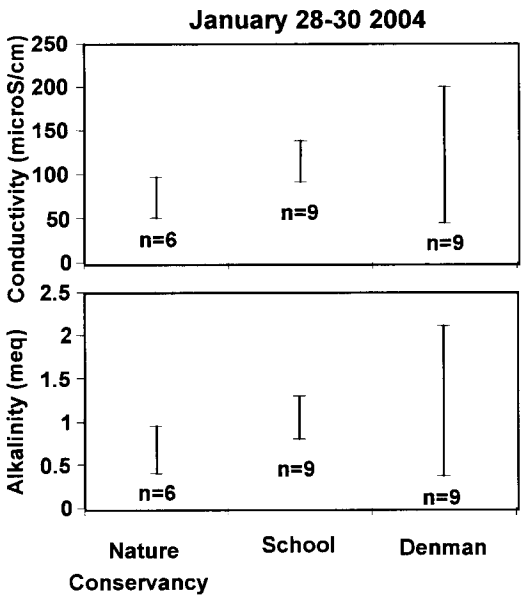

Fig. 1. Conductivity and alkalinity of several pools at each of the three sample sites.

tain undisturbed vernal pools with *B. lynchi* present. In addition, a portion of the site that did not originally contain vernal pools has been used to construct new vernal pools as mitigation for nearby pools eliminated by the expansion of the regional airport. The constructed pools were completed in September 2003 and have as yet not stabilized and contain no *B. lynchi*. Surrounding land use is predominantly a wildlife preserve with some light industry nearby, but with little direct influence on the site.

Water chemistry

Water samples were collected from pools at each of the three sites on four dates (30 December 2003, and 28–30 January, 26–27 February and 24–25 March 2004). Samples were analyzed for alkalinity, conductivity, cations and anions.

Results indicate that the pools within each of the sites are similar, as illustrated by the January samples (Fig. 1). Not unexpectedly, ion concentrations were lowest at the TNC site (least disturbed) and highest in the recently constructed pools of the Denman site (Table 1). The original undisturbed pools on the Denman site resembled the pools of the TNC site. Ion concentrations were somewhat higher in the pools of the School Site, possibly reflecting the recent history of disturbance to the site or the runoff from the adjacent upslope residential area. In general, calcium was the most abundant cation, followed by sodium, magnesium and finally potassium. However, sodium was the most abundant cation in the newly constructed pools at the Denman site. In all cases, the most abundant anion was bicarbonate, followed by approximately equal concentrations of chloride and sulfate.

Concentrations remained nearly constant at each site until the last sampling date, 24–25 March, when many of the pools had already dried up and remaining pools contained higher concentrations of ions. Ion concentrations increased dramatically in the few remaining pools at both the School site and the Denman site. For example, the concentration of sodium

Table 1. Cation data. Mean values of cation concentrations in selected pools at each site for three sample dates (30 December 2003; 28–30 January 2004 and 26–27 February 2004). Units are millimolar. Range of values in parentheses.

Site	Observations	Calcium	Magnesium	Sodium	Potassium
The Nature Conservancy (TNC)	n=12 (4 pools × 3 dates)	**0.110** (0.078–0.206)	**0.074** (0.044–0.135)	**0.091** (0.053–0.146)	**0.022** (0.016–0.028)
School	n=15 (5 pools × 3 dates)	**0.217** (0.160–0.326)	**0.133** (0.093–0.179)	**0.160** (0.051–0.191)	**0.048** (0.029–0.063)
Denman	n=9 (3 pools × 3 dates)	**0.141** (0.088–0.218)	**0.087** (0.058–0.109)	**0.619** (0.083–1.547)	**0.032** (0.009–0.063)

increased to 2.427 mM in one of the constructed pools at the Denman site, well in excess of the mean concentrations observed earlier in the season. In contrast, the concentrations of ions in the remaining pools at the TNC site increased only slightly.

Much of the increased conductivity in the constructed pools of the Denman site is associated with particularly high concentrations of sodium (Table 1) and to a lesser extent potassium and chloride. Because ion chemistry has been reported to have a significant influence on fairy shrimp survival (GONZALEZ et al. 1996), the elevated sodium concentration observed in the newly constructed pools raises concerns about the adequacy of the pools as mitigation for loss of nearby pools. Overall however, ion concentrations in all of the pools of the Agate Desert are rather low and comparable to lakes and reservoirs in the region (JOHNSON et al. 1985).

Zooplankton communities

One-liter grab samples were collected from selected pools at their deepest point at the three sites 28–30 January, 26–27 February and 24–25 March 2004. The pools selected represent both naturally occurring and recently created pools. Each sample was concentrated by pouring through a 50-micron filtering screen and preserved in 70% isopropyl alcohol for later study to identify microcrustaceans to family and determine relative numbers of each group present. Because of the sampling method, we collected primarily taxa living in the water column.

The organisms encountered were representative of groups typically encountered in vernal pools (KEELER-WOLF et al. 1998, ZEDLER 1987), including Anostraca, Cladocera, Copepoda, Ostracoda and Rotifera. The overall community composition was similar in all the natural pools, as illustrated by the February sampling date (Fig. 2) when nearly all pools were hydrated. Although sampling was limited, there appeared to be a general progression over the season from small opportunistic rotifers, to copepods, cladocerans, Anostracans, and finally predatory insects.

In spite of recent disturbance at the School Site, all the groups were well represented and similar to the better protected Nature Conservancy site, suggesting that the quality of the habitat remains sufficient to allow the persistence of the species of interest, *B. lynchi*. In contrast, the created pools at the Denman site contained a smaller variety of species and typically contained more juvenile forms. Although the water chemistry of the created pools is somewhat different, and seasonal hydroperiods are still establishing, that may not be the most important reason for the depauperate zooplankton populations. Inoculation with soils from natural pools known to support the species of interest, or additional time for colonization by natural communities, will be required before the new pools can be considered suitable for common and endangered invertebrates, and can be deemed adequate mitigation for nearby habitat losses.

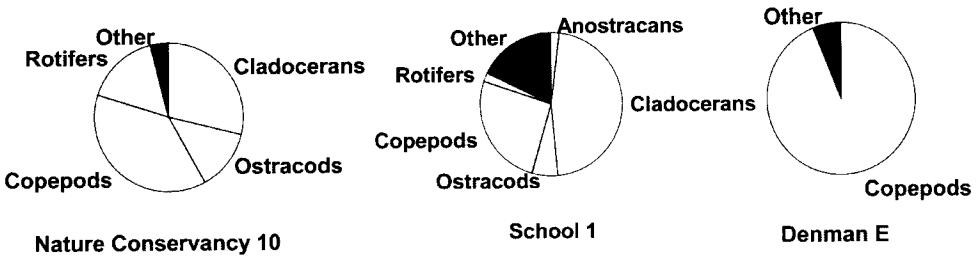

Fig. 2. Zooplankton collected from representative pools at each of the three sites, 26–27 February 2004. Denman E is a recently constructed pool.

Vegetation community

Vernal pools are wet long enough to be different in character and species composition from the surrounding upland habitats, yet their prolonged annual dry phase prevents the establishment of species typical of more permanent wetlands. The prairie mounds that are interspersed with the pools support upland plant communities that cannot tolerate extended wet conditions. Pool edges and lower flanks of the mounds are transition zones between the two moisture extremes. Vernal pools are known for their showy displays of spring wildflowers that bloom in concentric rings around the pools.

Plant species found in the Agate Desert vernal pools include the endangered annual forb *Limnanthes floccosa* ssp. *grandiflora* and the annual grasses *Alopecurus saccatus* and *Deschampsia danthodioides*. Representative upland species include the endangered perennial forb *Lomatium cookii*, the perennial forb *Viola douglasii*, and the annual forb *Clarkia purpurea*.

Summary

A process to identify and conserve vernal pool habitat of the Agate Desert in the northern Rogue Valley, Oregon, U.S.A., is underway and scheduled for completion in 2005. A program to monitor habitat characteristics and biota of protected vernal pools has been initiated. Initial results indicate that some of the pools at each of the sites provide suitable habitat for species of concern, but the newly constructed pools of the Denman site do not yet provide suitable habitat.

References

ALEXANDER, D.G. & SCHLISING, R.A., 1996: Patterns in time and space for rare macroinvertebrates and vascular plants in vernal pool ecosystems at the Vina Plains Preserve, and implications for pool landscape management. – In: WITHAM, C.W. (Ed.): Ecology, conservation and management of vernal pool ecosystems: 161–168. California Native Plant Society.

BELK, D., 1996: Global status and trends in ephemeral pool invertebrate conservation: implications for California Fairy Shrimp. – In: WITHAM, C.W. (Ed.): Ecology, conservation and management of vernal pool ecosystems: 147–150. – California Native Plant Society.

BOHONAK, A.J. & JENKINS, D.G., 2003: A Review: Ecological and evolutionary significance of dispersal by freshwater invertebrates. – Ecol. Lett. **6**: 783–796.

ELLIOT, M. & SAMMONS, D., 1996: Characterization of the Agate Desert. – Southern Oregon State College, Dept. of Geol., Ashland, Oregon.

GONZALEZ, R.J., DRAZEN, J., HATHAWAY, S., BAUER, B. & SIMOVICH, M., 1996: Physiological correlates of water chemistry requirements of fairy shrimps (Anostraca) from Southern California. – J. Crustac. Biol. **16**: 315–322.

HAIRSTON Jr, N.G., 1996: Zooplankton egg banks as biotic reservoirs in changing environments. – Limnol. Ocean. **41**: 1087–1092.

HANES, T. & STROMBERG, L., 1996: Hydrology of vernal pools on non-volcanic soils in the Sacramento Valley. – In: WITHAM, C.W. (Ed.): Ecology, conservation and management of vernal pool ecosystems: 38–49. California Native Plant Society.

JOHNSON, D., PETERSEN, R.R., LYCAN, R., SWEET, J.W., NEUHAUS, M.E. & SCHAEDEL, A.L., 1985: An Atlas of Oregon Lakes. – Oregon State Univ. Press., 328 pp.

KEELER-WOLF, T., ELAM, D.R., LEWIS, K. & FLINT, S.A., 1998. California vernal pools assessment preliminary report. Appendix C. Plant and animal taxa known to be associated with vernal pools. – Sacramento, CA: California Dept. of Fish and Game.

PHILIPPI, T.E., SIMOVICH, M.A., BAUDER, E.T. & MOORAD, J.A., 2001: Habitat ephemerality and hatching fractions of a diapausing anostracan (Crustacea: Branchiopoda). – Isr. J. Zool. **47**: 387–395.

RAINS, M.C., FOGG, G.E., HARTER T., DAHLGREN, R.A. & WILLIAMSON, R.J. (2006): The role of perched aquifers in hydrological connectivity and biogeochemical processes in vernal pool landscapes, Central Valley, California. – Hydrolog. Processes **20**: 1157–1175.

ZEDLER, P.H., 1987: The ecology of southern California vernal pools: a community profile. – National Wetlands Research Center, U.S. Fish and Wildlife Service, Washington, D.C.

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